

Cognitive Apprenticeship in Orthopaedic Surgery: Updating a Classic Educational Model



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OBJECTIVE: To define cognitive apprenticeship and describe how it can be applied to orthopedic education.

DESIGN: Traditional apprenticeships have been used through history as a teaching model for wide variety of skills. These apprenticeships are characterized by practical, on-the-job training in which the apprentice observes and assists a master in the completion of a task, and thereby learns the skills needed to complete that task on his or her own.

RESULTS: Cognitive apprenticeship is differentiated from the traditional apprenticeship model primarily by its educational goals. Cognitive apprenticeships are used to teach skills which require internal thought processes which cannot be readily observed externally by the teacher or the student.

CONCLUSION: Here, we review the history of the cognitive apprenticeship concept, its basic principles, its applications to a wide variety of educational circumstances, and its potential use a framework for developing orthopedic curricula. (J Surg Ed 76:931–935. © 2019 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

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INTRODUCTION

Traditional apprenticeships have been used through history as a teaching model for wide variety of skills.

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These apprenticeships are characterized by practical, on-the-job training in which the apprentice observes and assists a master in the completion of a task, and thereby learns the skills needed to complete that task on his or her own.

Cognitive apprenticeship is a modified version of this traditional teaching method first described by Brown et al.¹ It is differentiated from the traditional apprenticeship model primarily by its educational goals; cognitive apprenticeships are used to teach skills which require internal thought processes which cannot be readily observed externally by the teacher or the student. Therefore, they require specific efforts to bring the cognitive efforts of the teacher and the student into the open.

To that end, Collins et al. identified the 6 core features of a cognitive apprenticeship: (1) Modeling, in which the student watches the teacher complete a task; (2) Coaching, in which the teacher observes the student complete a task and offers suggestions and feedback; (3) Scaffolding, which refers to the learning supports provided to the student by the teacher, ranging from brief lessons to physical learning tools, such as simulations; (4) Articulation, which refers to methods used by the teacher to encourage the student to explicitly verbalize their thought process as they complete a task; (5) Reflection, in which the student compares their own skill level and ability to complete a task to that of the teacher; and (6) Exploration, in which advanced students are guided to develop their own solution to a problem or method of completing a task.² Combining these principles in an educational setting defines a cognitive apprenticeship, and allows teachers to pass down skills requiring both technical expertise and high level thinking, such as surgery (Table 1).

Many of these concepts have been employed in surgical education since the inception of the profession, even if not specifically named as such. Halsted's principles of surgical training, written over a century ago, emphasize

TABLE 1.

Principle	Explanation	Example
Modeling	Student observes teacher completing a task	Intern watches attending surgeon perform a total hip arthroplasty
Coaching	Teacher observes student completing a task, provides suggestions and feedback	Junior resident performs a total hip arthroplasty while attending surgeon provides direction and feedback
Scaffolding	Teacher provides learning supports to student to allow increased focus on learning specific principle or skill	Attending surgeon holds cadaver lab so residents can learn to perform a total hip arthroplasty in a controlled, low pressure environment
Articulation	Teacher encourages student to explicitly verbalize their thought processes as they complete a task	Attending surgeon asks midlevel resident to call out the next steps for a total hip arthroplasty as he or she performs the procedure
Reflection	Teacher encourages student to critically assess their own skills and/or knowledge base	Attending surgeon has senior resident provide feedback for him or herself after completing a total hip arthroplasty
Exploration	Student completes a task under minimal guidance, and allowed to develop their own problem solving methods when needed	Attending provides little to no feedback as fellow completes a total hip arthroplasty

the necessity of graduated responsibility for trainees under the watchful eye of an experienced surgeon.³

In a typical operating room at most modern academic medical centers the principles of cognitive apprenticeship are routinely employed. The completion of a case by an attending surgeon in the presence of a trainee is a simple but effective example of modeling. An attending surgeon guiding a trainee through the performance of a procedure is a similarly straightforward example of coaching. The intentional and unintentional help provided by the attending surgeon to a trainee during the completion of a procedure (discussing the procedure preoperatively, calling for instruments while the trainee works, and holding retractors) all serve as excellent scaffolds to support learning. Having the trainee verbalize the upcoming steps of a procedure is an example of articulation, while discussing the case postoperatively with the trainee offers an opportunity for reflection. Finally, giving more senior trainees increased autonomy in the operating room allows for exploration.

Here we review modern evidence supporting the use of the cognitive apprenticeship model for teaching a diverse group of skills to a wide variety of learners, and discuss the application of cognitive apprenticeship principles to orthopedic surgical training.

COGNITIVE APPRENTICESHIP IN ADVANCED TRAINING

Cognitive apprenticeship principles have been shown to be effective for teaching skills in a wide variety of settings, including writing skills in adult learners,^{4,5} math skills in postgraduate students,⁶ and advanced clinical skills in attending physicians.⁷

The first mentions of cognitive apprenticeships in medical settings are encountered in nursing literature.⁸⁻¹⁰ Preceptors trained to use modeling, coaching and scaffolding were shown to improve the capabilities and confidence of the nurses they taught.^{9,10}

More recently, a number of studies have described attempts to introduce cognitive apprenticeships into medical school and residency training. Such coursework has been shown to improve ability of medical students to read chest radiographs, to perform basic life support skills and independently take call.¹¹⁻¹³ Simulation based learning, a powerful example of scaffolding, has been shown to especially effective for teaching a wide range of procedural skills.^{14,15}

There is also recognition that the principles of cognitive apprenticeship have been widely applied in medical education without being specifically named as such. Numerous interview and survey studies have shed light on the experience of educators and students with

cognitive apprenticeship concepts.¹⁶⁻¹⁹ Olmos-Vega surveyed 215 residents across various subspecialties, the majority of whom had experience some, if not all of the cognitive apprenticeship principles during their education. Junior residents tended to respond most favorably toward modeling, coaching and scaffolding, while more senior residents tended to favor an approach based on articulation, reflection, and exploration.¹⁷ Stalmeijer interviewed educators, who recognized these principles as pre-existing parts of their own educational philosophy.¹⁸ These educators noted that cognitive apprenticeships are easier to develop during longer rotations with closer teacher/trainee interaction.

Stalmeijer felt strongly enough about the value of cognitive apprenticeships that he, along with his group, developed an objective evaluation tool for clinical educators based on their use, conscious or not, of cognitive apprenticeship principles.²⁰ The result, The Maastricht Clinical Teaching Questionnaire, has been validated in a clinical setting at least twice, most recently with veterinary clinical educators.²¹

COGNITIVE APPRENTICESHIP IN ORTHOPEDIC SURGERY

Although, to our knowledge, there are no studies in the orthopedic surgery literature in which the cognitive apprenticeship model was formally applied, there are a number of studies which employed some of the cognitive apprenticeship principles without naming them as such.

For example, Karam et al. described a teaching exercise in which trainees performed an open reduction internal fixation on a sawbones tibial plateau fracture model while wearing a head-mounted camera.²² They subsequently reviewed those videos with an attending surgeon, allowing an opportunity for coaching, articulation, and reflection. Those trainees who received this coaching session performed significantly better on their second attempt to reduce and fix the sawbones model. Jain et al. also used video footage as a means of allowing residents and attendings to engage in low pressure coaching sessions, this time for closed reductions in the emergency department.²³ Residents surveyed thought these sessions were valuable educational tools.

Karam et al. also described multimodal teaching efforts, aimed at providing students with a combination of practical experience and academic teaching.²⁴ They compared groups of residents who received trauma lectures only, a trauma rotation only, or a combination of a trauma rotation and lectures; perhaps unsurprisingly, the third group improved their OITE trauma scores by more than the first 2. This demonstrates the power of teaching efforts combining practical experience, which

allows for modeling, coaching, and exploration, with didactic elements, which allow for reflection, articulation, and scaffolding. A similar study by Robinson et al. split medical students into groups which received lectures only, lectures with observation of cadaveric dissection, or lectures with hands on cadaveric dissections.²⁵ Although at the conclusion of the study there were no differences in objective measures of medical student performance on practical testing, students in the group which received lectures and hands on experiences rated the educational value of their experience higher than students in the other groups.

Additionally, numerous groups have found scaffolding in the form of simulation-based education to be a highly effective method for teaching a wide range of skills, including cast saw use,²⁶ arthroscopy,²⁷ distal radius reduction,²⁸ and drill use.²⁹ The simulation tools developed by the authors of these studies allowed their trainees to practice skills in a focused and low pressure environment. In this way they serve as excellent examples of scaffolding, which is defined by the provision of learning supports to trainees until they are ready to independently complete a task.

The combination of simulation learning with more traditional teaching techniques, including modeling and coaching sessions, has also been shown to be effective for teaching skills such as ACL graft preparation³⁰ and pediatric supracondylar humerus fixation.³¹ Bhattacharyya et al. developed a focused, practical audiovisual course for teaching residents to properly perform a diagnostic knee arthroscopy; this course was found to be highly effective when tested in a simulation model.³²

DISCUSSION

Orthopedic surgeons need to learn a vast array of academic concepts and procedural techniques during their limited time in residency and fellowship. This time is further limited in the current era of work hour restrictions, which have been shown, at least in the general surgery literature, to decrease residency case volumes.³³ A training tradition of “low-density learning interactions while logging countless hours in service of the hospital,” as described by Pelligrini et al., is no longer possible.³⁴ Instead, focus should be on maximizing the impact of any and all available training time.

The cognitive apprenticeship model, with its core principles of modeling, coaching, scaffolding, articulation, reflection, and exploration, offers a flexible framework for high-impact clinical teaching. It can be especially effective when used longitudinally; early in a resident’s career the principles of modeling, coaching and scaffolding can be employed primarily, while more

experienced residents can be granted progressive autonomy while still receiving feedback from their teachers through lessons based on articulation and reflection. Finally, the most experienced residents and fellows can be allowed to move on to exploration, and work on problem solving with minimal guidance.

As demonstrated above, the principles of cognitive apprenticeship have already been used in orthopedic training and reported in the literature without being named as such. Ideally, educators can use the framework of cognitive apprenticeships to expand on these efforts, and develop comprehensive educational programs in a variety of clinical settings. These can range from shorter modules for teaching specific skills to multiyear programs for teaching residents the principles of entire subspecialties. We believe the development, testing, and reporting of such programs for potential proliferation would be of significant value to orthopedic education as a whole.

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SUPPLEMENTARY INFORMATION

Supplementary material associated with this article can be found in the online version at <https://doi.org/10.1016/j.jsurg.2019.01.009>.